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CLIMB AND HIGH-SPEED TESTS OF A CURTISS NO. 714-1C2-12 FOUR-BLADE PROPELLER ON THE REPUBLIC P-47C AIRPLANE

By A. W. Vogeley

Langley Memorial Aeronautical Laboratory
Langley Field, Va.

NACA

WASHINGTON

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INTRODUCTION

As part of a program of flight tests of several propellers on the Republic P-47C airplane for the purpose of determining climb and high-speed characteristics, tests have been made of a Curtiss No. 714-1C2-12 four-blade propeller. Results of these tests and a brief analysis are presented herein.

The climb tests consisted of runs at normal rated power, indicated airspeeds of 160 and 165 miles per hour, and altitudes from sea level to about 30,000 feet and runs at military power, an indicated airspeed of 165 miles per hour, and altitudes from sea level to about 23,000 feet. High-speed tests consisted of a series of runs covering a Mach number range from 0.4 to 0.7 at approximately constant power and rotational speed and a series of runs at a Mach number of 0.7 and constant rotational speed with varying power. In order to determine the effects of compressibility, the efficiencies measured in the high-speed runs were compared with those measured in runs made at the same power coefficient and advance-diameter ratio but at a Mach number of about 0.3.

SYMBOLS

V	true airspeed
n	propeller rotational speed, revolutions per second
D	propeller diameter
J	advance-diameter ratio (V/nD)
β	section blade angle at 0.75R
θ	blade angle at any section
R	propeller-tip radius
r	propeller-section radius
b	blade-section chord

h blade-section thickness

r_s radial distance from thrust axis to survey point

$x_s = \frac{r_s}{R}$

p_o free-stream static pressure

p_{T_o} free-stream total pressure

Δp_T difference between slipstream total pressure and free-stream total pressure

T propeller thrust

Q propeller torque

C_T propeller thrust coefficient

C_P propeller power coefficient

η propeller efficiency

σ ratio of density of free air to density of air at sea level

ρ density of free air

M airplane Mach number

M_t propeller-tip Mach number

PROPELLER AND TEST EQUIPMENT

General specifications of the propeller and power plant are as follows:

Number of blades	Four
Blade design	Curtiss No. 714-102-12
Blade sections	Clark Y
Propeller diameter	12 feet, 2 inches
Propeller gear ratio	2:1
Engine	Pratt & Whitney R-2800-21

[redacted]

Military-power rating of engine:
- Engine speed, rpm 2700
- Manifold pressure, inches of mercury 52
- Horsepower 2000
- Critical altitude, feet . . . . (approx.) 27,000

Normal-power rating of engine:
- Engine speed, rpm 2550
- Manifold pressure, inches of mercury 42
- Horsepower 1625
- Critical altitude, feet . . . . (approx.) 29,000

The propeller, as tested, was equipped with the standard production cooling cuffs. Blade-form curves are presented in figure 1.

Propeller thrust was measured by the slipstream total-pressure survey method. For this purpose two survey rakes, connected to NACA recording multiple manometers, were mounted horizontally on either side of the fuselage at the rear of the engine cowling, as shown in figure 2. A photograph of the airplane, propeller, and survey rakes is presented as figure 3.

Propeller torque was measured with a standard Pratt & Whitney torque meter, to which was connected a standard NACA pressure recorder. An indicating pressure gage was mounted in the cockpit for use by the pilot. Standard NACA recording instruments were used to record engine speed, impact pressure, static pressure, and free-air temperature. Propeller blade angle was measured with a special NACA spark-type blade-angle recorder.

TEST PROCEDURES

Climb tests.- With engine speed, manifold pressure, and indicated airspeed adjusted to the desired values, short records on all instruments were taken at intervals of 2000 feet as the airplane climbed from sea level to altitude.

Climbs were made under the following conditions:

(1) Military power at normal climbing indicated airspeed of 165 miles per hour

(2) Normal power at indicated airspeed of 160 miles per hour

(3) Normal power at indicated airspeed of 165 miles per hour

The climb at military power was terminated at the relatively low altitude of 23,000 feet because of insufficient engine cooling indicated by high cylinder-head temperature.

High-speed tests.- Each high-speed run was made at values of engine speed, torque, indicated airspeed, and pressure altitude selected to produce a desired combination of values of airplane Mach number, propeller advance-diameter ratio, and power coefficient. Because the airplane was usually either climbing or diving during a run, only engine speed, torque, and airspeed could be fixed. These values were therefore held constant as the airplane passed through the desired altitude, when a short record was taken.

The low-speed runs ($M \approx 0.3$), used as a basis for determining the effects of compressibility, were made in the same manner as the high-speed runs.

REDUCTION OF DATA

True airspeed, airplane Mach number, and air density were obtained by standard reduction methods from the recorded values of impact pressure, static pressure, and indicated free-air temperature. Engine speed, torque, and propeller blade angle were recorded directly.

Propeller power coefficient was calculated by the formula

$$C_P = \frac{2\pi Q}{\rho n^2 D^5}$$

Propeller-tip Mach number was obtained from the equation

$$M_t = M\sqrt{1 + \left(\frac{\pi}{J}\right)^2}$$

Propeller thrust coefficient was evaluated from the measurements of slipstream total pressure by the method described in reference 1, which gives

$$\frac{dT}{\pi\, d\left(r_s^2\right)} = \left(\frac{p_o}{p_{T_o}}\right)^{5/7} \Delta p_T \tag{1}$$

In order to obtain the nondimensional quantities used in the present report, equation (1) was reduced as follows:

$$\frac{dC_T}{d\left(x_s^2\right)} = \frac{dT}{\pi\, d\left(r_s^2\right)} \frac{\pi}{4} \frac{1}{\rho n^2 D^2}$$

The areas under the curves of $dC_T/d\left(x_s^2\right)$ against x_s^2 are equal to the thrust coefficients.

RESULTS AND DISCUSSION

Climb tests.- The variations of blade angle, advance-diameter ratio, power and thrust coefficients, efficiency, and propeller-tip and airplane Mach numbers with density altitude for the climbs are presented in figures 4 to 6. These flight data are also given in table I.

In each of the climbs, changes in propeller efficiency with altitude appear to be small. Except for a slight initial increase, efficiency tends to decrease with altitude. This decrease is to be expected, since the operating lift coefficients of the blade sections increase with increasing altitude and approach the stall region; the final result is to reduce the section lift-drag ratios and to lower the efficiency.

Compressibility effects become evident in each of the climbs whenever the propeller-tip Mach number exceeds about 0.86. Thrust-grading curves for climb at normal power and an indicated airspeed of 160 miles per hour are presented in figure 7 to show these effects of compressibility at high propeller-tip Mach numbers. The effects of compressibility are not evident in runs 20-1 to 20-11, in which tip Mach numbers are below 0.85 (figs. 7(a) to 7(f)). The first effects are evident on the right side of the propeller disk for run 20-12 (fig. 7(g)), in which the tip Mach number has reached 0.86. These effects continue to increase with tip Mach number. Little or no evidence of compressibility loss exists on the left side of the propeller disk, probably because the left side is less heavily loaded than the right side owing to inclination of the thrust axis to the air stream. To the extent, therefore, that the disk load distribution is affected, the tip Mach number at which compressibility effects first become evident is influenced by the airplane attitude with respect to the flight path.

The term "compressibility effects" as used herein means the effects shown by changes in the general shape of the thrust-grading curves, for example, the dip in the curve between $x_s^2 = 0.6$ and $x_s^2 = 0.9$ as measured with the right survey rake in run 20-15 (fig. 7(h)). The term does not include the effect that causes the grading curves for both the right and left surveys to approach zero at the tip at different values of x_s^2. This effect is directly attributable to an unintentional yawed attitude of the airplane held during the run, which causes the slipstream to be displaced laterally at the survey rakes.

Losses in thrust due to compressibility are present at the higher tip Mach numbers but no marked decrease in efficiency attributable to this cause is apparent. With further increases in altitude that result in higher section lift coefficients and Mach numbers, however, it is expected that the losses would extend over an increasing part of the disk area and that the effect on efficiency would become significant. Compressibility losses can be delayed by reducing the tip blade angles. This reduction would result in a transfer of load to the inboard sections, which operate at lower Mach numbers and can therefore absorb the additional load without serious compressibility effects. The inboard shift of load would also tend to bring the blade loading into closer agreement with the theoretically ideal load distribution for a propeller operating at low advance-diameter ratios; thus the possibility of a reduction in induced losses exists. The use of this method is suggested only if particular emphasis is put on climb performance, since large losses in efficiency at high speed may result.

Since in the range of advance-diameter ratio for climb the propeller operates at power coefficients greater than the values for maximum efficiency, it is generally recognized that either a reduction in power coefficient or an increase in advance-diameter ratio is necessary to increase efficiency. These methods are illustrated by comparing the efficiency levels (at tip Mach numbers below 0.86) of the climbs (figs. 4 to 6).

In the military-power climb (fig. 4), the propeller operates at an efficiency of about 76 percent. By reducing the power coefficient at essentially the same advance-diameter ratio, as in the normal-power climb at an indicated airspeed of 160 miles per hour (fig. 5), the propeller efficiency is increased to approximately 80 percent. An additional gain in efficiency of about 3 percent is achieved by increasing the airplane speed and thereby increasing the advance-diameter ratio, as in the climb of figure 6. These gains in efficiency are due primarily to reductions in the section lift coefficients that cause the sections to operate at lift-drag ratios approaching the optimum. The climb performance of the airplane is, of course, not improved by the increase in propeller efficiency because of the large reduction in power required to effect the increase. In order to improve the airplane climb performance, a propeller designed to absorb military power at these higher section lift-drag ratios is necessary; in effect, an increase in solidity is required.

High-speed tests.- In order to determine the effects of compressibility on propeller operation at constant power, two series of runs were made at airplane Mach numbers ranging from 0.4 to 0.7. One series was made at a power coefficient of about 0.35, which corresponds approximately to military-power operation at critical altitude (27,000 ft). The second series was made at a power coefficient of about 0.29, which corresponds to military power at an altitude of about 18,000 feet. The data obtained in these tests are given in table II.

The propeller efficiencies measured at high speeds are compared in figure 8 with the efficiencies measured at low speed ($M \approx 0.3$) in runs covering the same ranges of power coefficient and advance-diameter ratio. The low-speed tests are summarized in figure 9, which shows the variation of propeller efficiency with power coefficient and advance-diameter ratio.

At the propeller speed used in the runs of figure 8, losses in efficiency due to compressibility apparently begin at an airplane Mach number below 0.4, increase steadily, and reach 10 to 11 percent at an airplane Mach number of 0.7. The corresponding propeller-tip Mach numbers range from about 0.95 to 1.07.

The effect of propeller-tip Mach number on efficiency is shown in figure 10, in which the ratio of high-speed efficiency to low-speed efficiency is given as a function of the high-speed propeller-tip Mach number. Figure 10 shows that losses in efficiency begin at $M_t \approx 0.88$, which is in close agreement with the results of the climb tests. The efficiency loss due to compressibility is shown to increase at the rate of about 7 percent for an increase of 0.1 in tip Mach number.

Thrust-grading curves of runs at a power coefficient of 0.35 are presented in figure 11. As in the climb runs, only the right side of the propeller disk shows any appreciable compressibility loss (fig. 11(a)). As the Mach number is increased, however, compressibility losses also become evident on the left side (fig. 11(b)). With further increase in Mach number, the losses become larger and extend inboard over a greater portion of the propeller blade.

The thrust-grading curve of a run made at an airplane Mach number of about 0.5 and at a reduced rotational speed is presented in figure 12. The advance-diameter ratio and power coefficient are approximately the same as those of figure 11(f). The marked difference in the shape of these grading curves indicates the extent of the losses in the high-speed run of figure 11(f). Figure 12 may also be compared with figure 11(b). These two runs were made at roughly the same power coefficient and airplane Mach number. The curves for the two runs illustrate how compressibility losses may be reduced by decreasing the propeller rotational speed and thereby reducing the section Mach numbers. By reducing the rotational speed, the propeller efficiency is increased about 4 percent or about one-half the increase to be expected from the reduction in tip Mach number alone (fig. 10). This difference indicates that the propeller-tip Mach number alone does not determine the magnitude of the compressibility losses.

The effect of loading on the propeller efficiency at high speed was investigated by making a series of runs at an airplane Mach number of about 0.7 and constant propeller speed with varying power. The results of these tests are compared in figure 13 with the results taken from figure 9 of low-speed tests at the same advance-diameter ratio and power coefficients. The extrapolated point in figure 13 was determined by first extending the curve for the high-speed tests $(C_P \approx 0.35)$ in figure 8 to an airplane Mach number of 0.7 and an advance-diameter ratio of 2.6. The value of efficiency obtained was then corrected to an advance-diameter ratio of 2.7 by using the curve for the low-speed tests $(C_P \approx 0.35)$ of figure 8. As the power is reduced the propeller efficiency decreases at both low and high speeds. The compressibility loss at high speed, as measured by the difference in high-speed and low-speed efficiency, appears to be relatively independent of power and is about 10 to 14 percent throughout the range investigated.

The effect of compressibility is to reduce the lift coefficient for maximum section efficiency as the critical Mach number is exceeded. A decrease in power would, consequently, be expected to cause a reduction in compressibility loss. In this case; however, some sections of the propeller are apparently operating at approximately maximum efficiency and some, at lift coefficients above those for maximum efficiency. Under such circumstances a reduction in power would result in a decrease in efficiency of some sections and an improvement in efficiency in others; the over-all effect would be only a small change in compressibility loss. Figure 14 shows that the tip sections are operating at highest efficiency at high power, since as the power is reduced the tip sections produce a decreasing amount of thrust in comparison with the inboard sections. Some gain in high-speed efficiency could probably be obtained by an adjustment in load distribution.

A comparison of the results of the high-speed and low-speed tests indicates that, in order to prevent large losses in efficiency, blade-section Mach numbers must be limited by reducing the rotational speed. At the same time, however, any adverse effect due to the increase in section lift coefficients necessary to absorb the same engine power at a lower rotational speed must be avoided by a proper increase in propeller solidity.

CONCLUSIONS

Flight tests of the Curtiss No. 714-1C2-12 four-blade propeller on a Republic P-47C airplane indicated the following conclusions:

1. In climbs at an indicated airspeed of 165 miles per hour, from 5 to 8 percent was lost in efficiency by increasing from normal to military power, primarily because of the reductions in section lift-drag ratio that resulted from increased operating lift coefficients.

2. With military power, losses in efficiency due to compressibility started at an airplane Mach number less than 0.4, increased steadily, and reached 10 to 11 percent at an airplane Mach number of 0.7. Compressibility losses became evident whenever the propeller-tip Mach number exceeded about 0.88, and the propeller efficiency decreased at a rate of about 7 percent for an increase of 0.1 in tip Mach number.

3. At an airplane Mach number of 0.7, a reduction in engine power below military power resulted in a lower propeller efficiency, but the loss in efficiency due to compressibility (based on low-speed tests at a corresponding advance-diameter ratio) was relatively independent of power.

4. By suitably increasing the solidity and reducing the rotational speed, an improvement in the propeller efficiency in both climb and high-speed operation may be possible.

Langley Memorial Aeronautical Laboratory
National Advisory Committee for Aeronautics
Langley Field, Va.

REFERENCE

1. Vogeley, A. W.: Flight Measurements of Compressibility Effects on a Three-Blade Thin Clark Y Propeller Operating at Constant Advance-Diameter Ratio and Blade Angle. NACA ACR No. 3G12, 1943.

[redacted]

TABLE I

FLIGHT DATA OBTAINED FROM CLIMB TESTS OF CURTISS NO. 714-1C2-12 FOUR-BLADE PROPELLER

Fig.	Run	J	C_P	C_T	η	n (rps)	M	M_t	σ	β (deg)
4	29-1	0.94	0.146	0.122	0.783	22.52	0.233	0.812	0.923	26.6
4	29-2	.96	.179	.139	.750	22.63	.240	.818	.858	28.4
4	29-3	.99	.187	.145	.764	22.62	.246	.823	.805	28.9
4	29-4	1.02	.200	.151	.768	22.44	.255	.825	.756	29.9
4	29-5	1.05	.212	.154	.761	22.50	.264	.834	.709	30.8
4	29-6	1.08	.230	.160	.750	22.44	.274	.845	.662	31.6
4	29-7	1.12	.238	.162	.758	22.37	.284	.850	.629	32.4
4	29-8	1.13	.253	.165	.736	22.54	.290	.869	.592	33.3
4	29-9	1.19	.273	.171	.744	22.49	.306	.865	.553	34.3
4	29-10	1.22	.289	.178	.749	22.61	.320	.882	.512	35.2
4	29-11	1.26	.302	.179	.748	22.49	.334	.896	.489	36.2
5, 7(a)	20-1	.94	.140	.116	.779	21.21	.223	.782	.968	26.4
5	20-2	.99	.150	.121	.798	21.29	.237	.790	.903	27.6
5, 7(b)	20-3	1.00	.165	.132	.799	21.36	.240	.793	.838	28.6
5	20-4	1.06	.191	.146	.810	21.20	.254	.792	.775	30.2
5, 7(c)	20-5	1.08	.189	.140	.798	21.52	.263	.812	.731	30.4
5	20-6	1.09	.195	.143	.802	21.78	.271	.828	.692	31.1
5, 7(d)	20-7	1.15	.213	.150	.806	21.49	.284	.825	.648	32.2
5	20-8	1.17	.228	.156	.799	21.50	.290	.833	.610	32.9
5, 7(e)	20-9	1.20	.240	.159	.790	21.74	.302	.849	.566	33.8
5	20-10	1.26	.261	.168	.813	21.52	.317	.852	.528	34.8
5, 7(f)	20-11	1.28	.272	.168	.791	21.43	.323	.852	.506	35.8
5, 7(g)	20-12	1.36	.303	.178	.799	21.15	.342	.861	.467	37.0
5	20-13	1.41	.318	.183	.808	21.44	.357	.874	.424	37.8
5	20-14	1.44	.337	.185	.786	21.55	.370	.891	.397	39.1
5, 7(h)	20-15	1.46	.346	.186	.787	21.48	.388	.920	.388	40.0
6	18-1	1.00	.145	.118	.816	21.25	.237	.780	.942	27.2
6	18-2	1.01	.158	.126	.809	21.37	.241	.788	.889	28.0
6	18-3	1.07	.171	.133	.838	21.16	.254	.786	.832	29.0
6	18-4	1.11	.184	.137	.820	21.36	.264	.794	.764	30.2
6	18-5	1.15	.196	.145	.847	21.22	.274	.799	.726	30.7
6	18-6	1.16	.205	.149	.845	21.53	.283	.818	.683	31.6
6	18-7	1.20	.220	.153	.833	21.50	.294	.825	.645	32.4
6	18-8	1.24	.237	.156	.819	21.43	.305	.833	.604	33.7
6	18-9	1.28	.252	.163	.822	21.45	.317	.843	.565	34.4
6	18-10	1.32	.269	.168	.822	21.37	.330	.851	.531	35.3
6	18-11	1.34	.279	.170	.819	21.60	.344	.874	.499	36.2
6	18-12	1.37	.296	.176	.811	21.48	.350	.875	.470	37.2
6	18-13	1.42	.320	.178	.791	21.51	.368	.882	.438	38.3
6	18-14	1.48	.332	.181	.808	21.58	.389	.922	.407	39.2
6	18-15	1.54	.366	.191	.801	21.40	.405	.922	.384	40.4
6	18-16	1.56	.379	.186	.764	21.65	.420	.952	.357	41.2

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TABLE II

FLIGHT DATA OBTAINED FROM HIGH-SPEED TESTS OF

CURTISS NO. 714-1C2-12 FOUR-BLADE PROPELLER

Fig.	Run	J	C_P	C_T	η	n (rps)	M	M_t	σ	β (deg)
11(a)	24-6	1.59	0.343	0.171	0.792	22.62	0.431	0.952	0.416	39.8
11(b)	24-5	1.84	.347	.151	.801	22.47	.495	.979	.416	41.4
11(c)	24-1	2.08	.352	.134	.786	22.44	.557	1.009	.418	44.1
11(d)	24-2	2.21	.351	.121	.759	22.46	.594	1.035	.422	45.3
11(e)	24-3	2.45	.358	.107	.735	22.30	.655	1.064	.422	47.5
11(f)	24-4	2.47	.346	.099	.708	22.48	.666	1.077	.432	47.9
14(a)	17-1	2.69	.144	.021	.395	22.62	.711	1.092	.576	----
-----	17-2	2.77	.151	.026	.482	22.08	.712	1.075	.560	----
-----	17-3	2.70	.164	.030	.500	22.32	.702	1.079	.575	----
14(b)	17-4	2.73	.176	.031	.476	22.20	.706	1.077	.569	----
-----	17-5	2.75	.204	.040	.543	22.03	.705	1.069	.557	----
-----	18-17	2.68	.216	.051	.636	22.30	.701	1.078	.539	47.8
14(c)	18-18	2.67	.221	.046	.557	22.28	.693	1.070	.545	47.8
-----	20-18	2.58	.256	.060	.609	23.31	.699	1.100	.551	47.2
14(d)	21-9	2.68	.282	.071	.672	22.42	.695	1.071	.541	----
-----	21-10	2.55	.290	.080	.704	22.45	.662	1.047	.521	----
-----	21-11	2.32	.292	.096	.758	22.47	.604	1.015	.523	----
-----	21-12	2.14	.291	.108	.797	22.41	.554	.984	.527	----
-----	21-13	1.95	.295	.122	.803	22.49	.508	.960	.515	----
12	12-1	2.54	.330	.109	.842	17.81	.505	.803	.716	----

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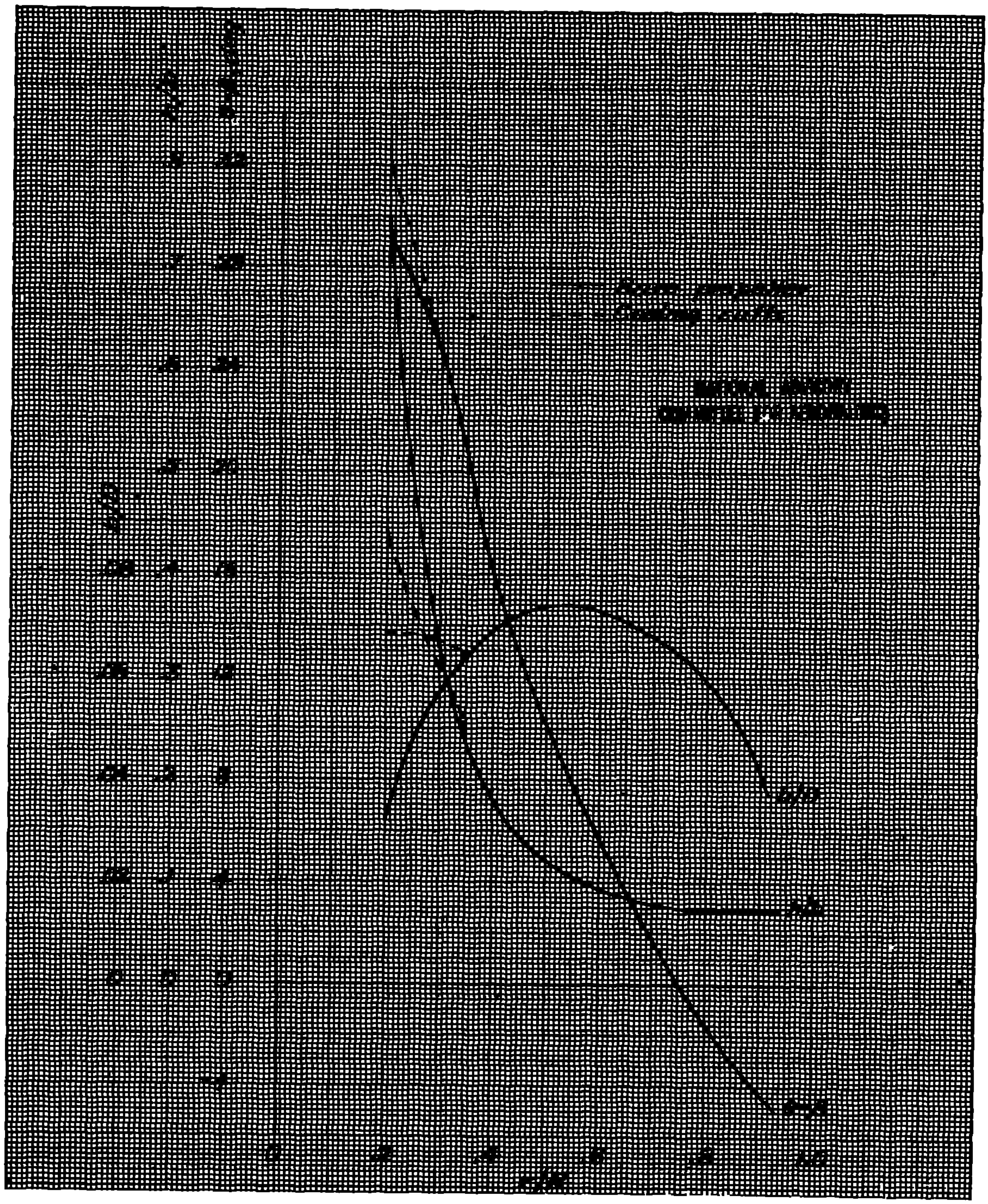


Figure 1 - Blade-form curves for Curtiss No. 714-1C2-12 four-blade propeller.

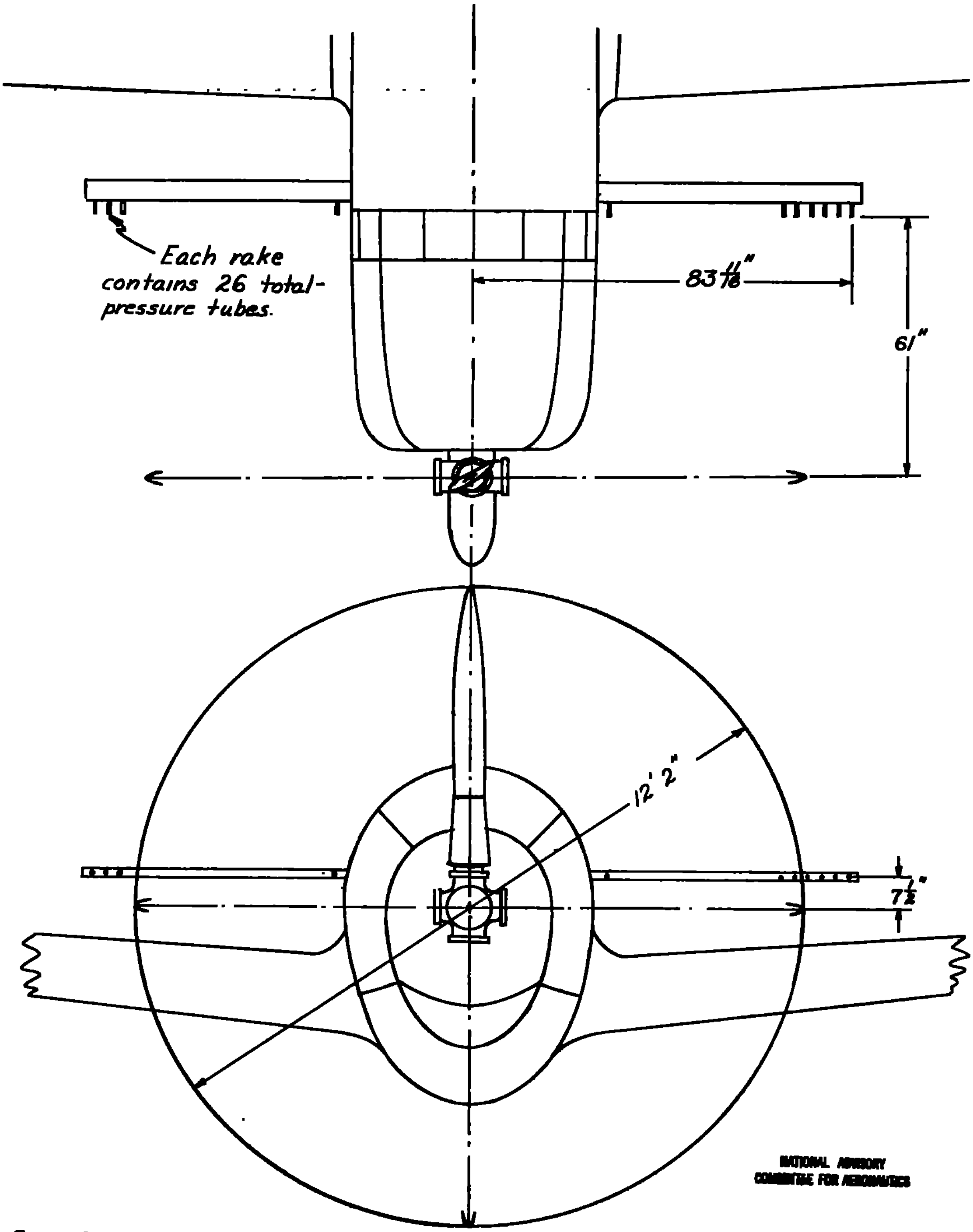


Figure 2.- Location of propeller and survey rakes on a Republic P-47C airplane.

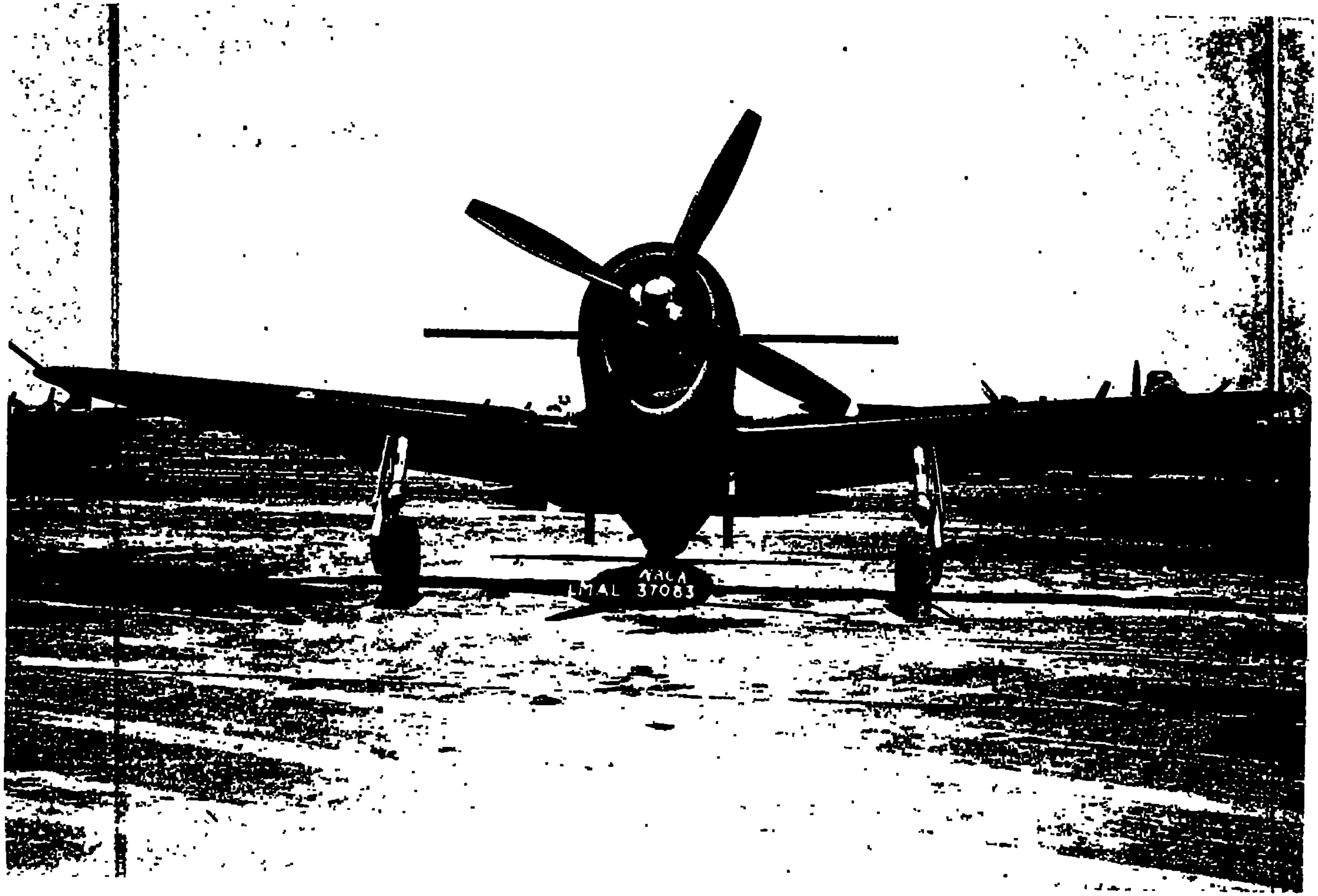


Figure 3.- Republic P-47C airplane equipped with a Curtiss No. 714-1C2-12 four-blade propeller and survey rakes.

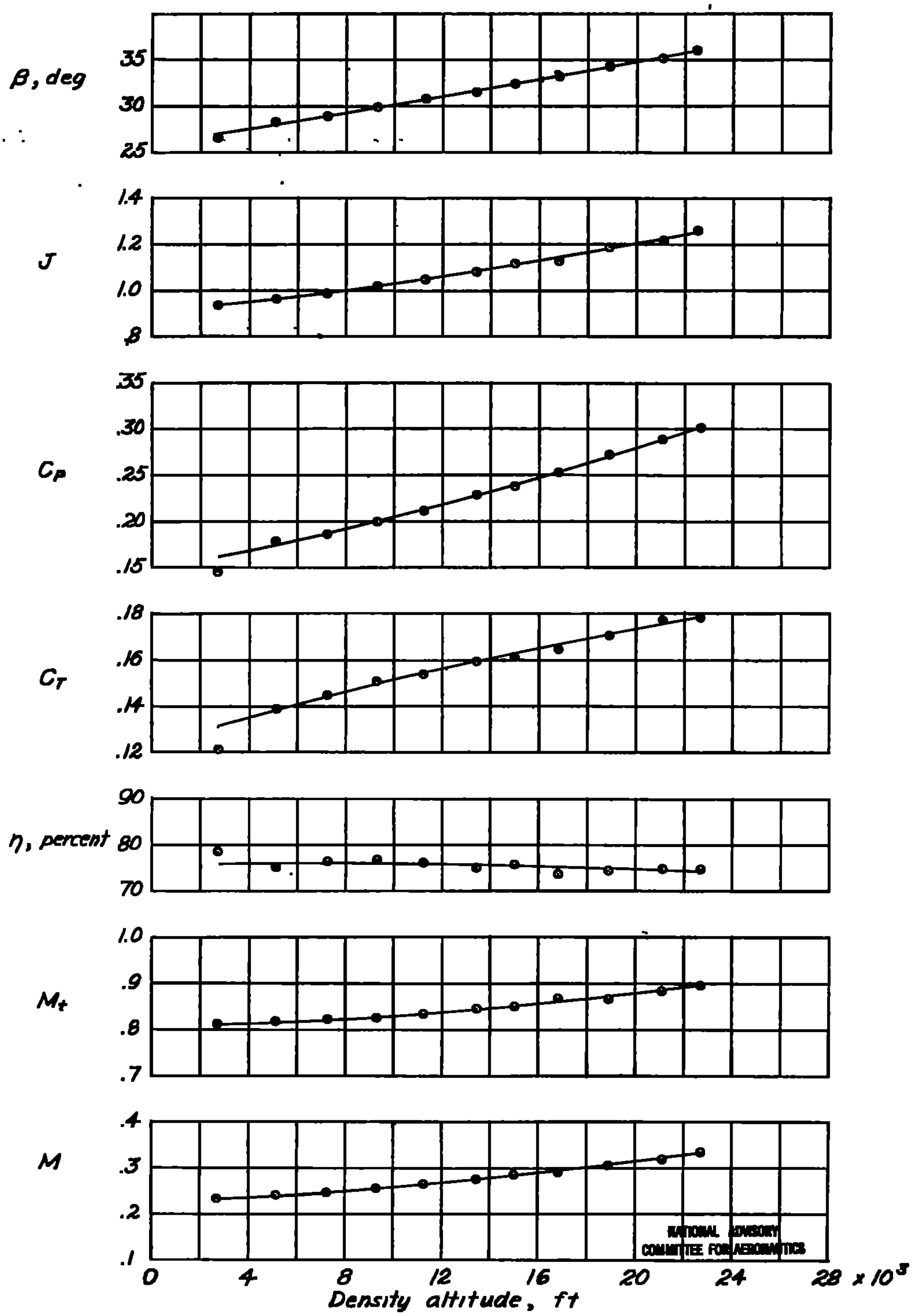


Figure 4.- Military-power climb at an indicated airspeed of 165 miles per hour. Curtiss No. 714-1C2-12 four-blade propeller on Republic P-47C airplane.

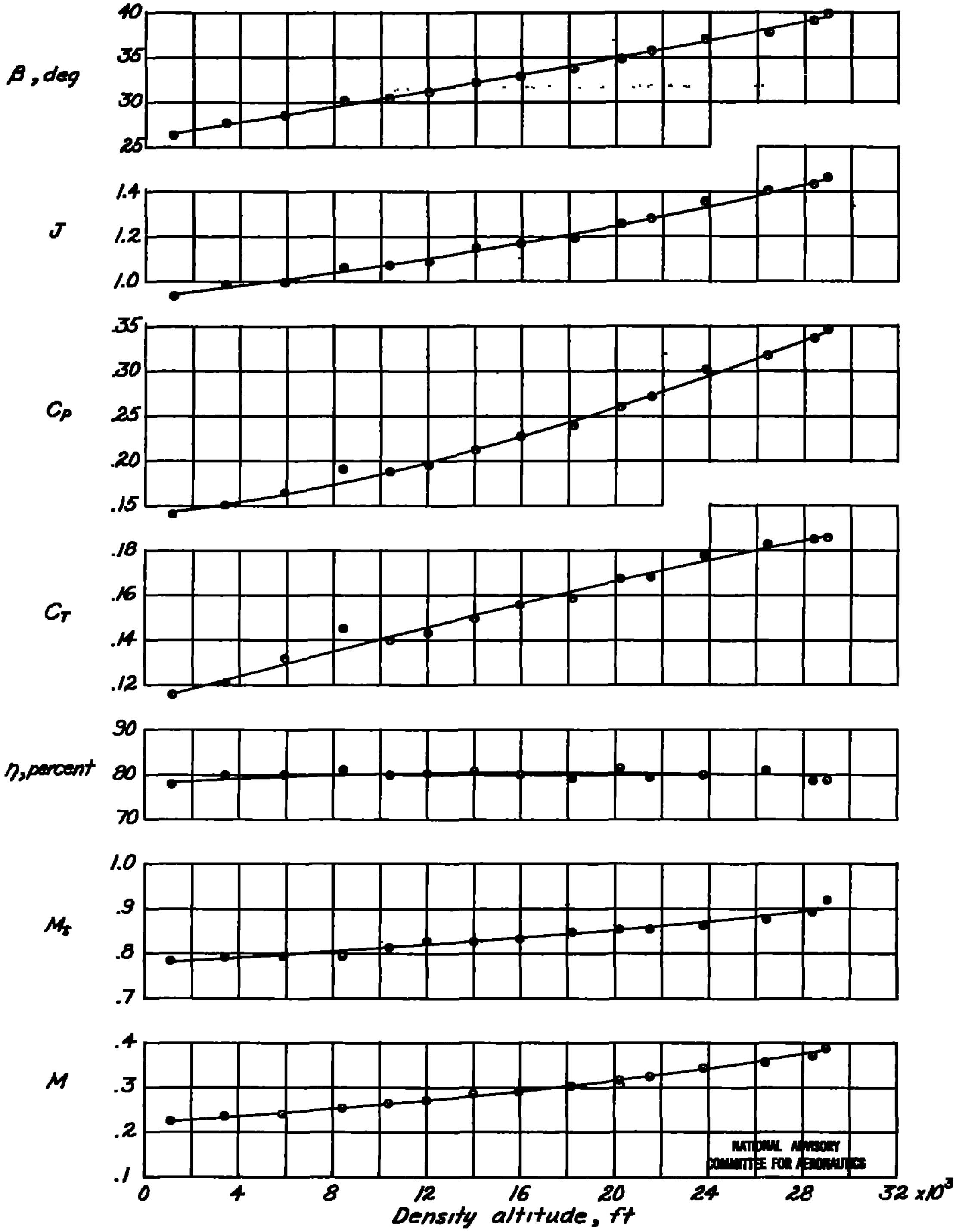


Figure 5.- Normal-power climb at an indicated airspeed of 160 miles per hour. Curtiss No. 714-1C2-12 four-blade propeller on Republic P-47C airplane.

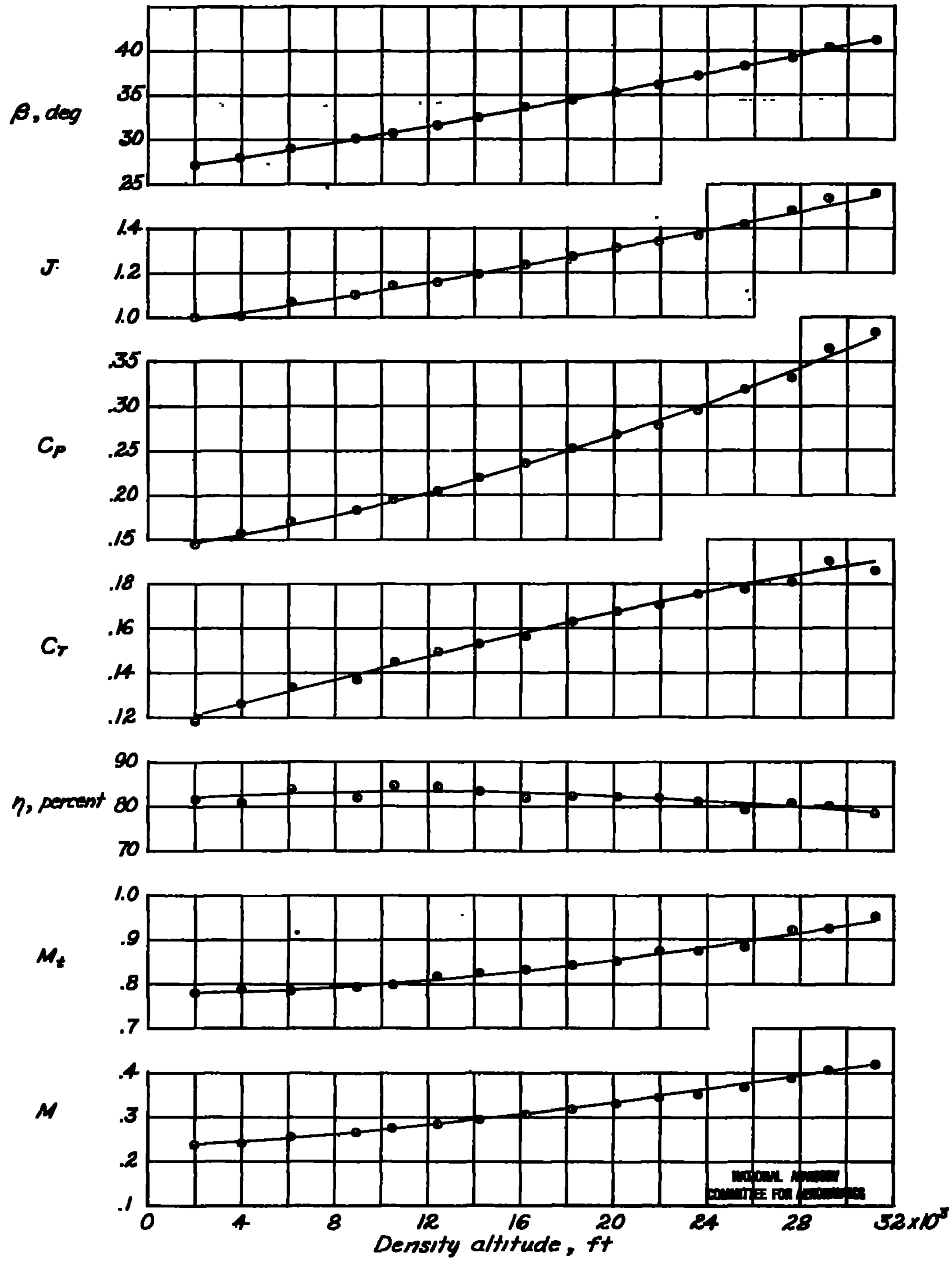
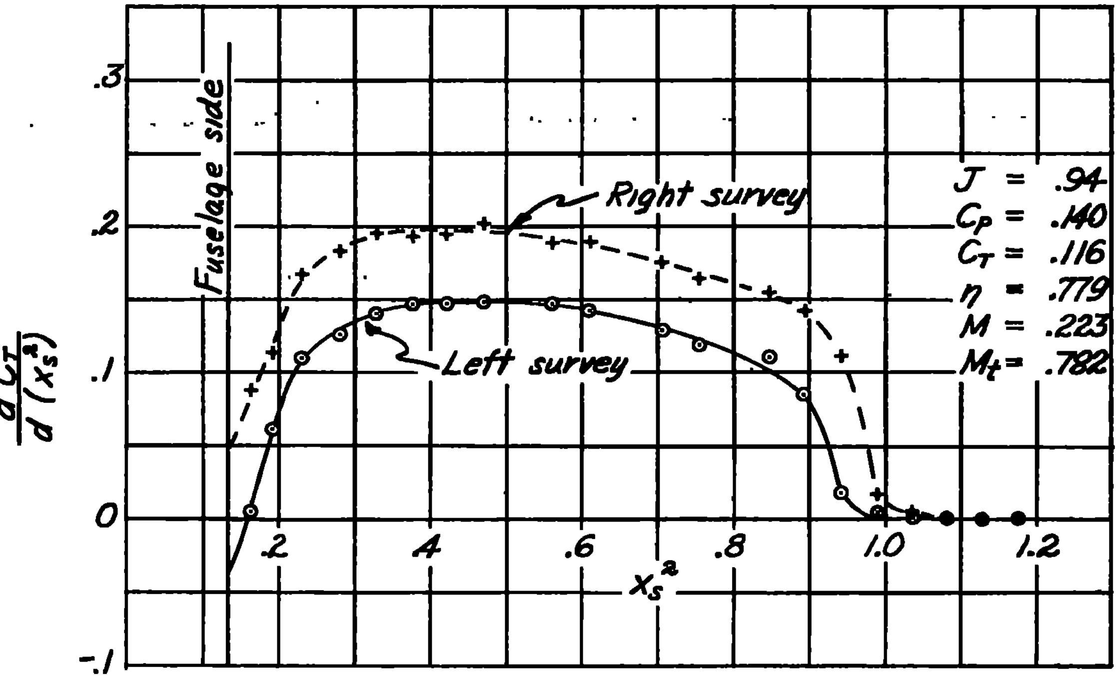
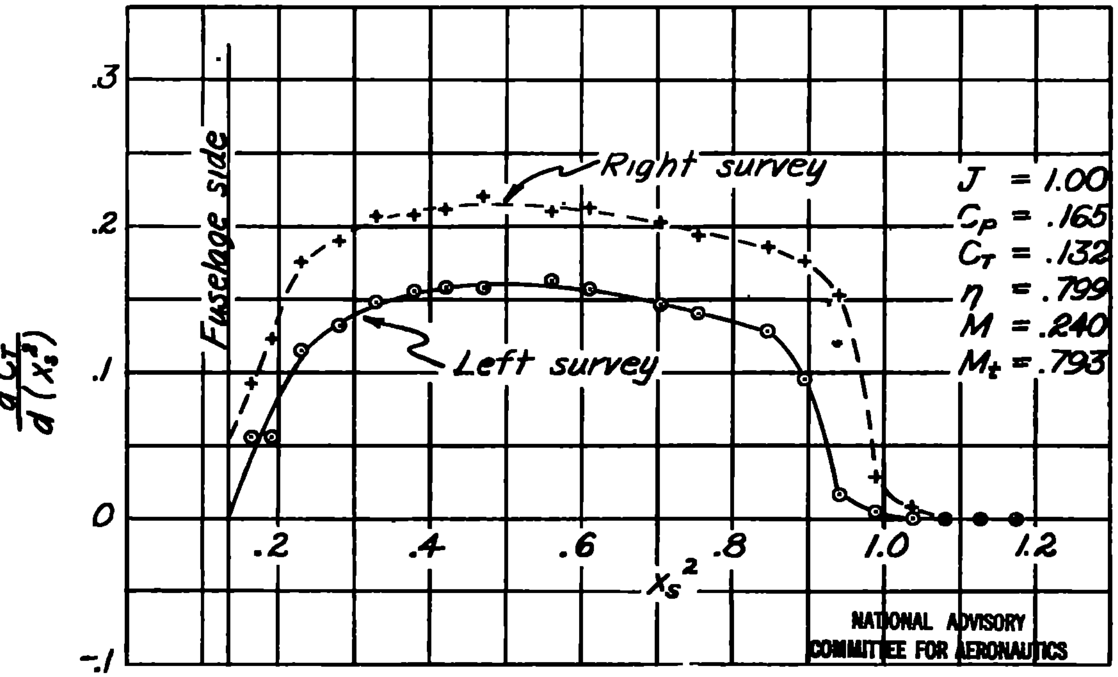


Figure 6.- Normal-power climb at an indicated airspeed of 165 miles per hour. Curtiss No. 714-1C2-12 four-blade propeller on Republic P-47C airplane.

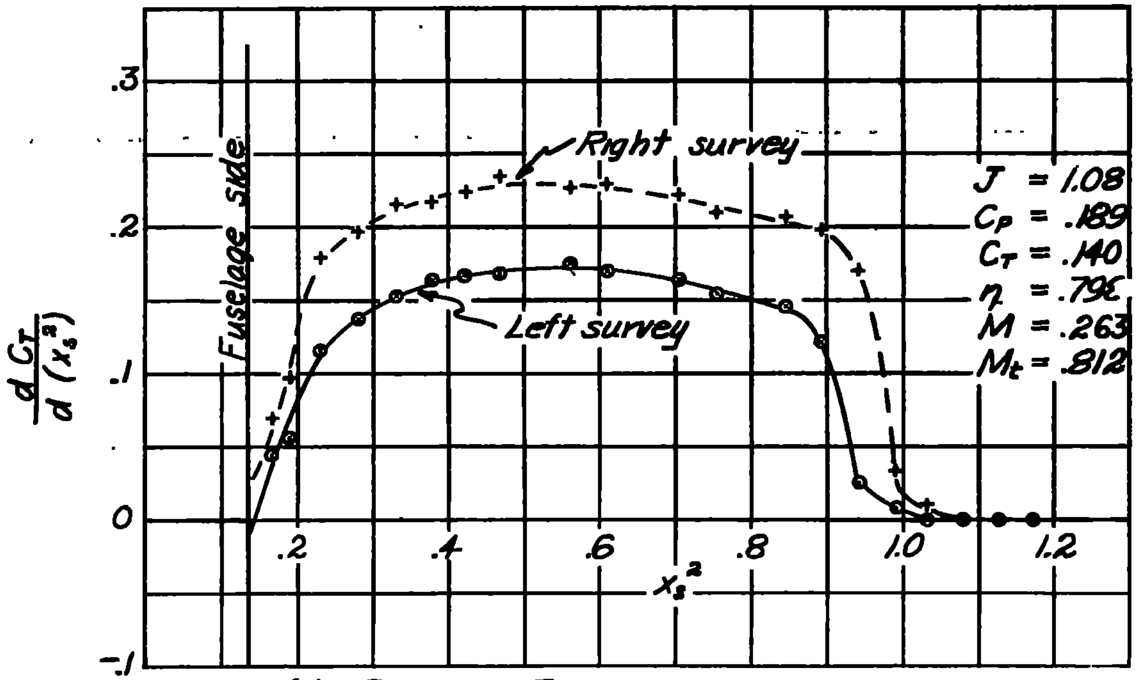


(a) Run 20-1.

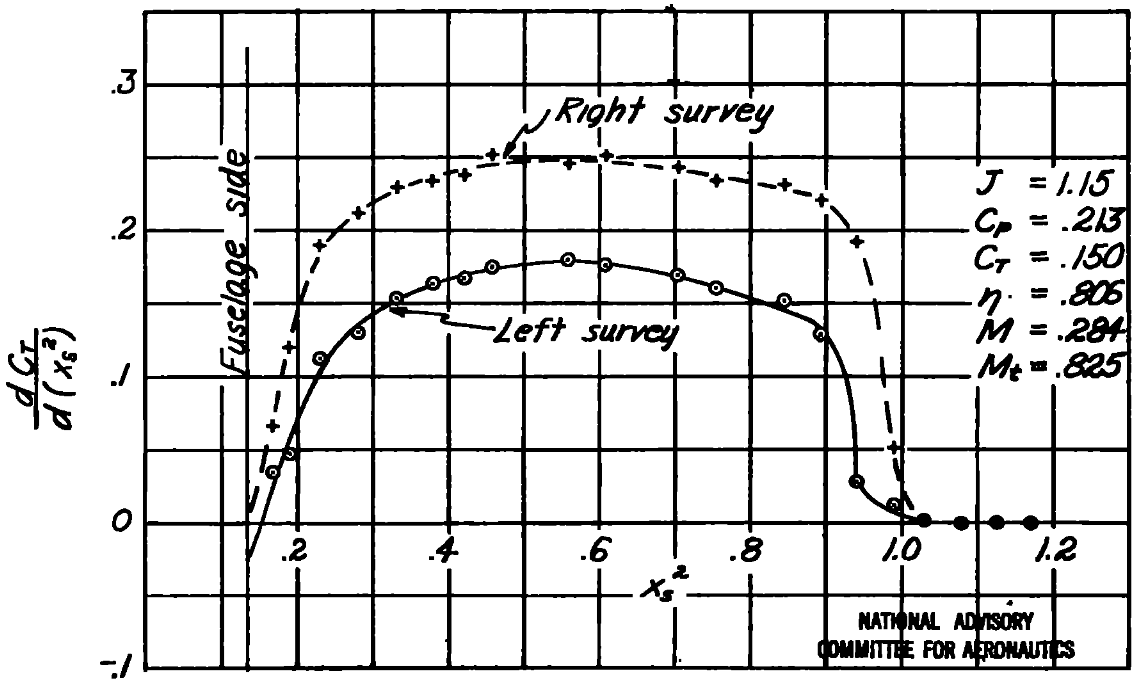


(b) Run 20-3.

Figure 7.- Thrust-grading curves for climb at normal power. Indicated airspeed, 160 miles per hour.

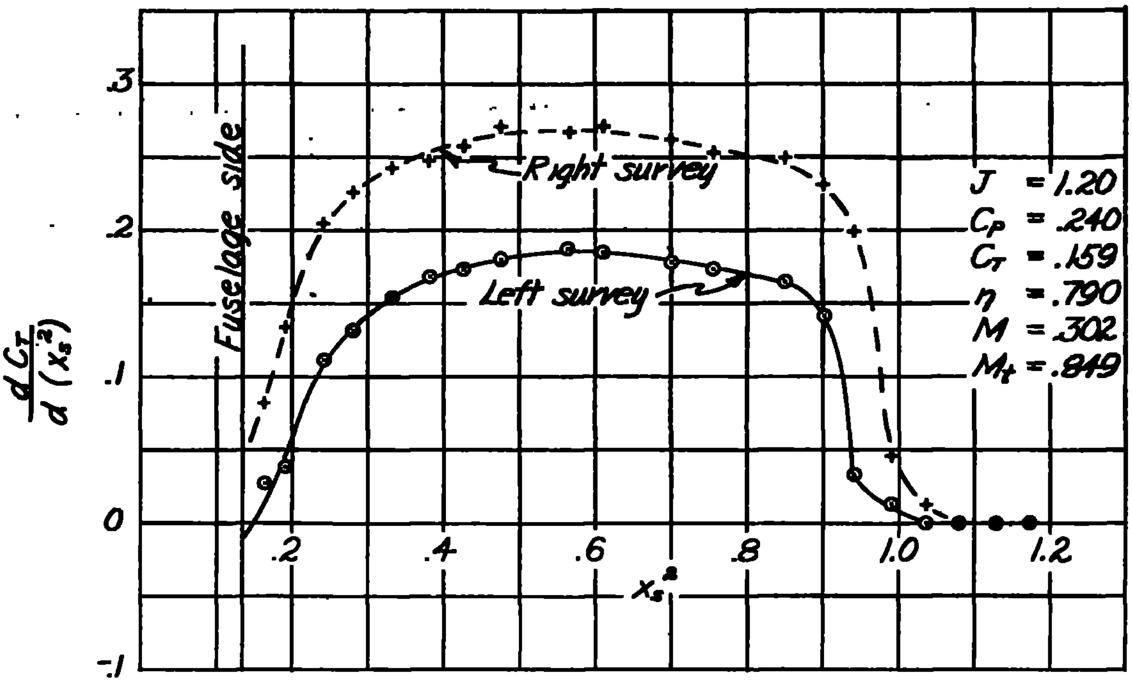


(c) Run 20-5.

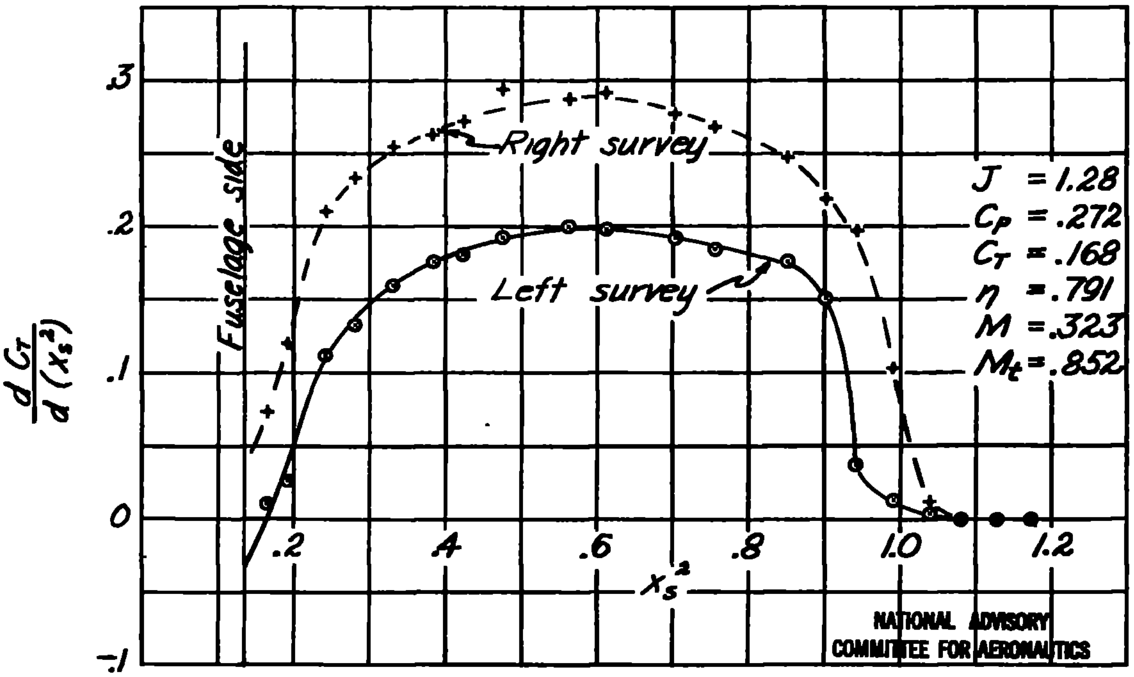


(d) Run 20-7.

Figure 7.- Continued.

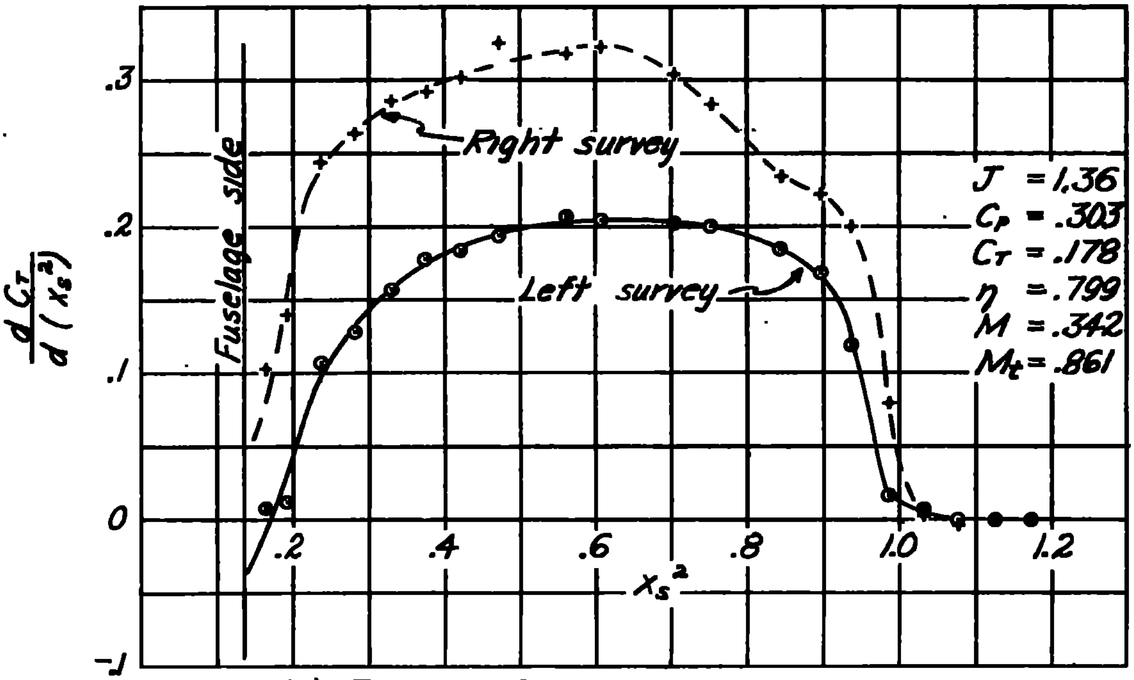


(e) Run 20-9.

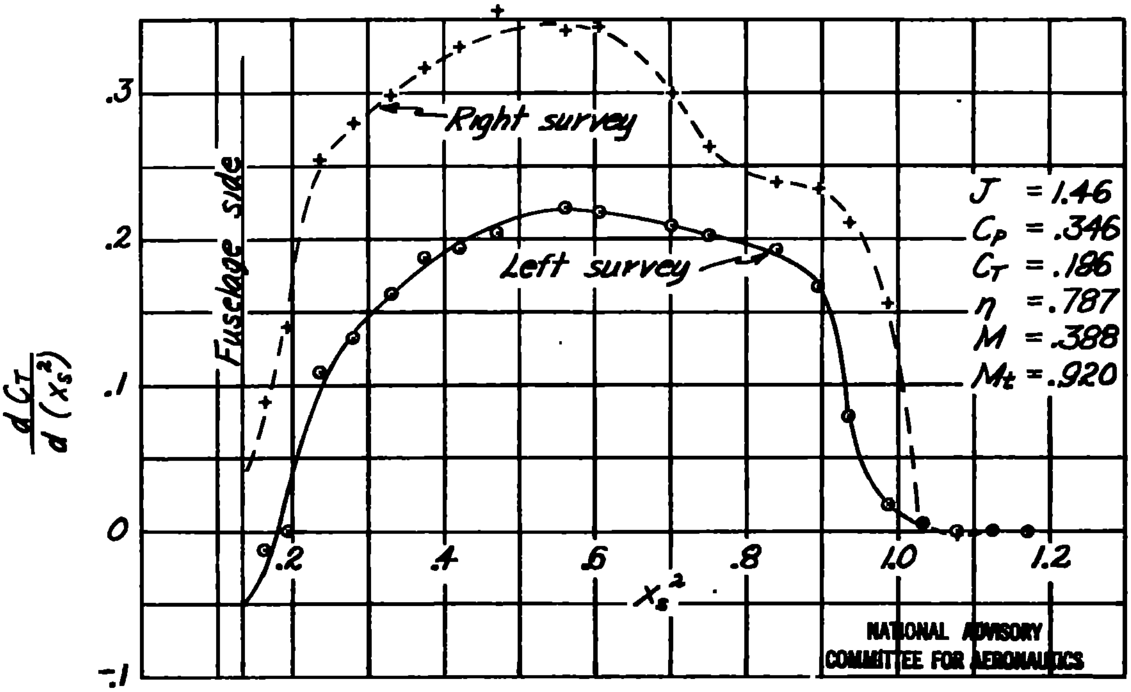


(f) Run 20-11.

Figure 7.- Continued.



(g) Run 20-12.



(h) Run 20-15.

Figure 7. - Concluded.

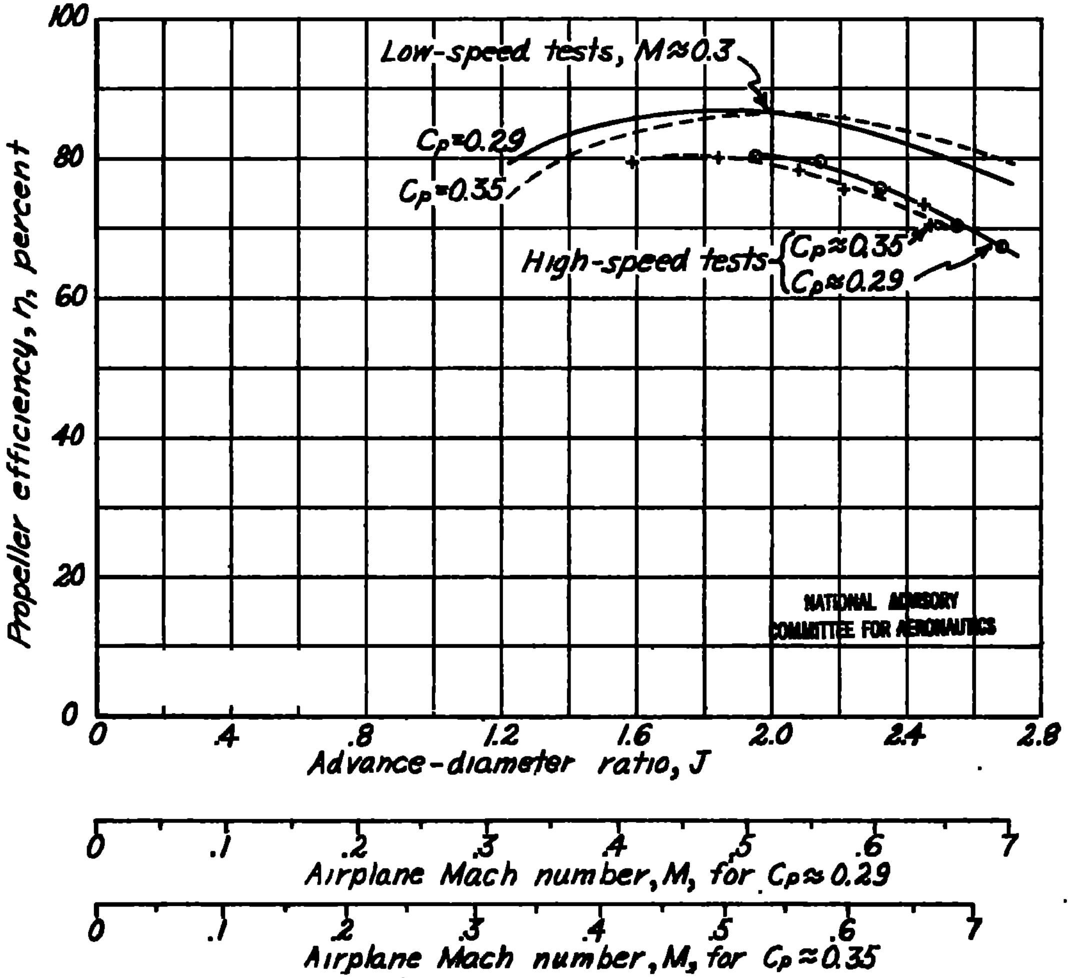


Figure 8.- Effect of compressibility on propeller efficiency for constant power coefficient. $C_P \approx 0.29$ and $C_P \approx 0.35$.

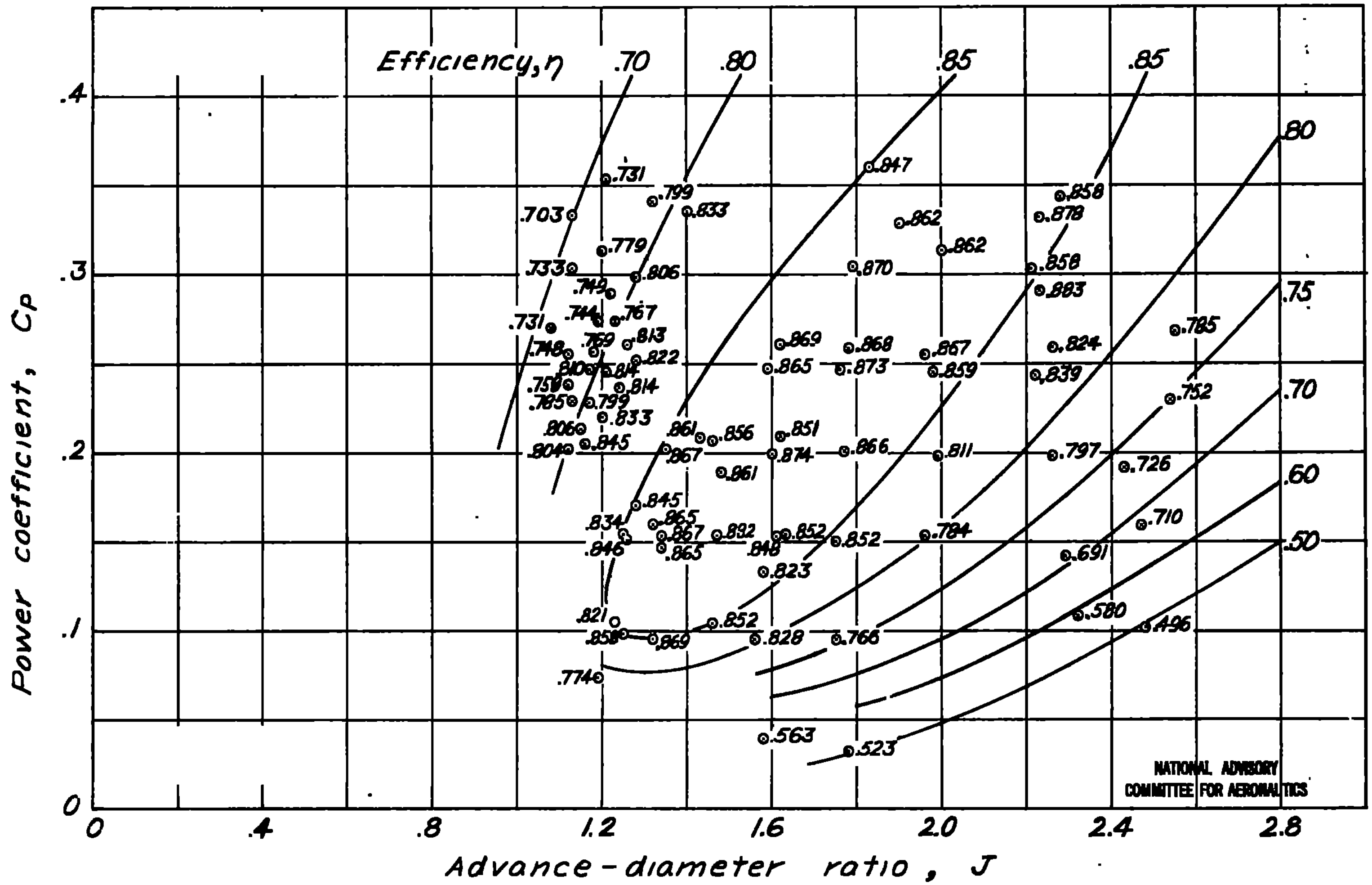


Figure 9.- Characteristics of a Curtiss No. 714-1C2-12 four-blade propeller on a Republic P-47C airplane. $M \approx 0.3$. (Measured values of efficiency are given for each point.)

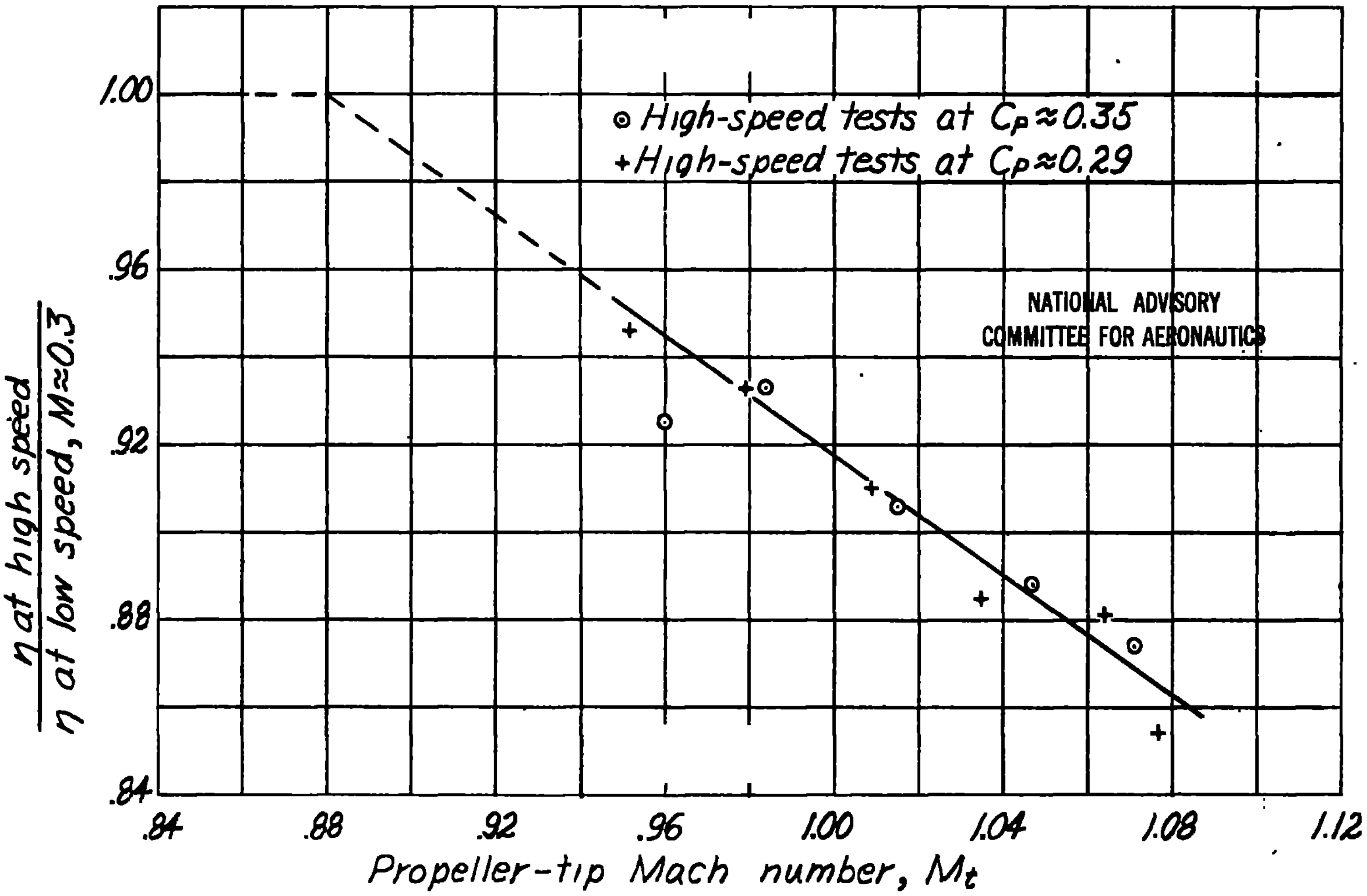
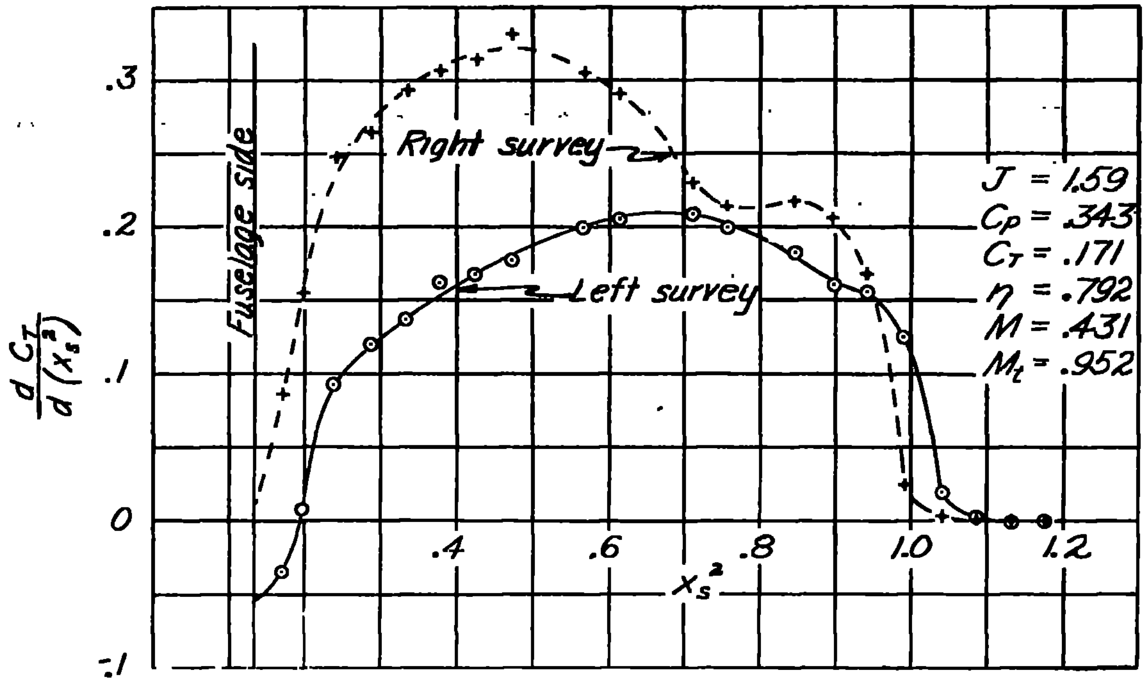


Figure 10.- Effect of propeller-tip Mach number on propeller efficiency at constant rotational speed.



(a) Run 24-6.

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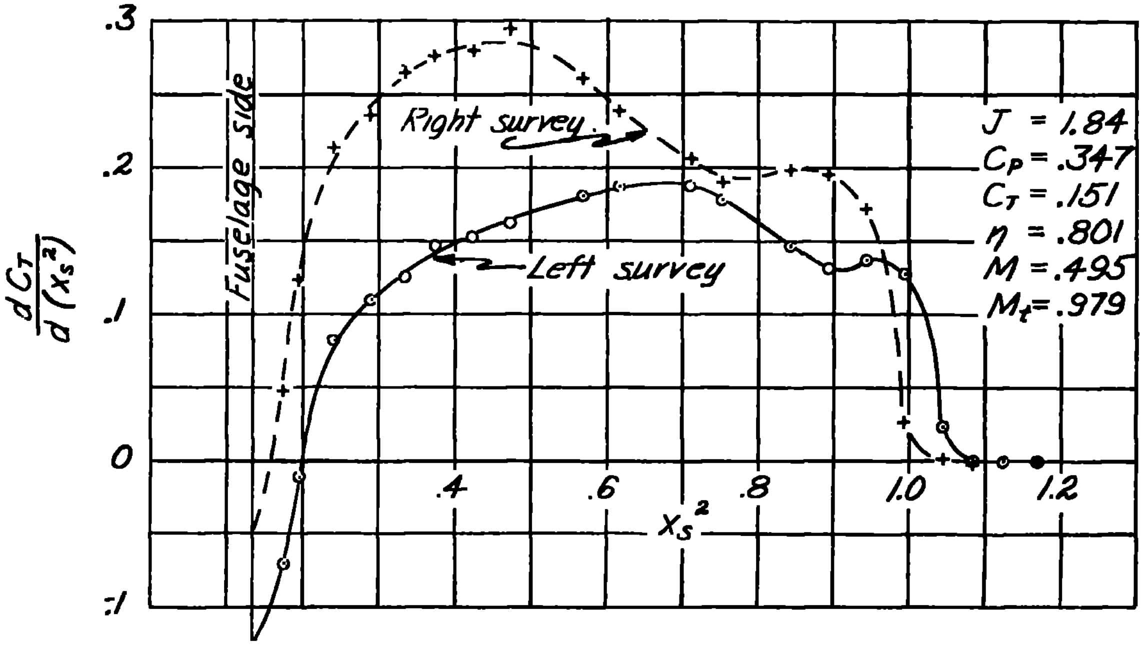
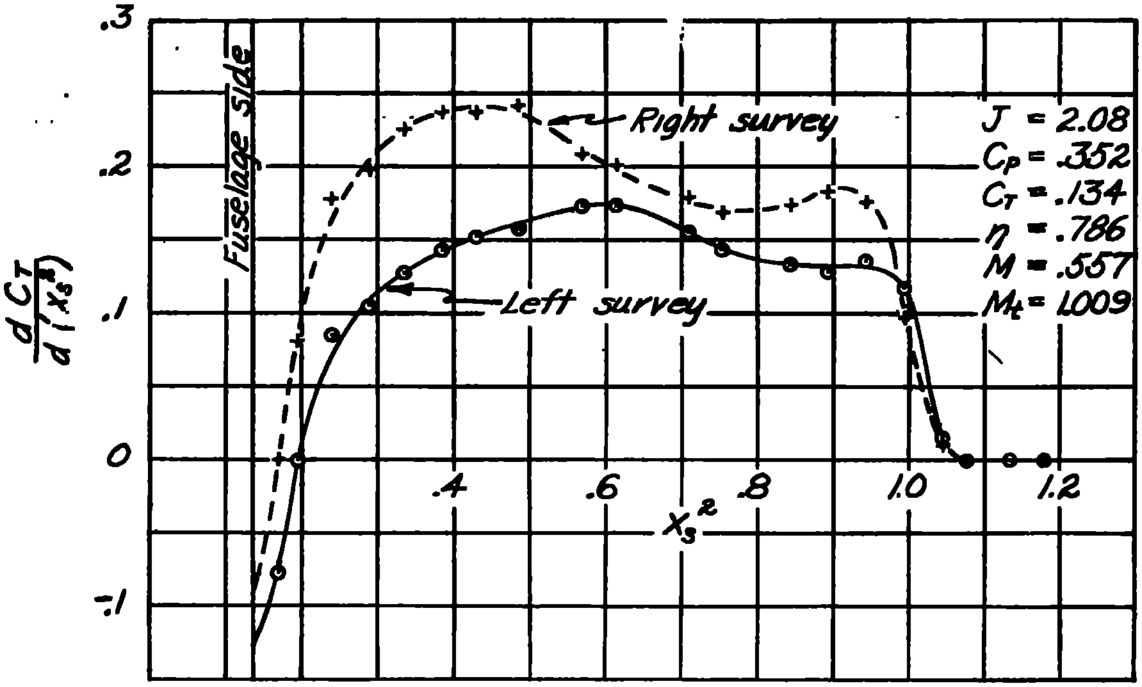
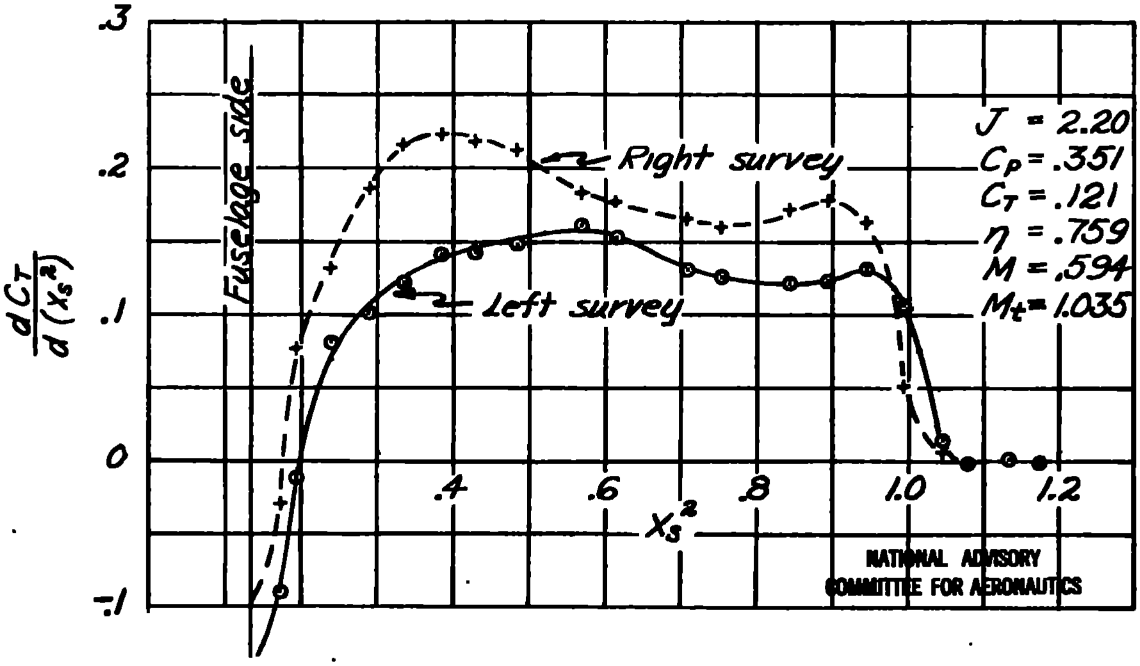


(b) Run 24-5.

Figure 11.- Thrust-grading curves for $C_P \approx 0.35$.

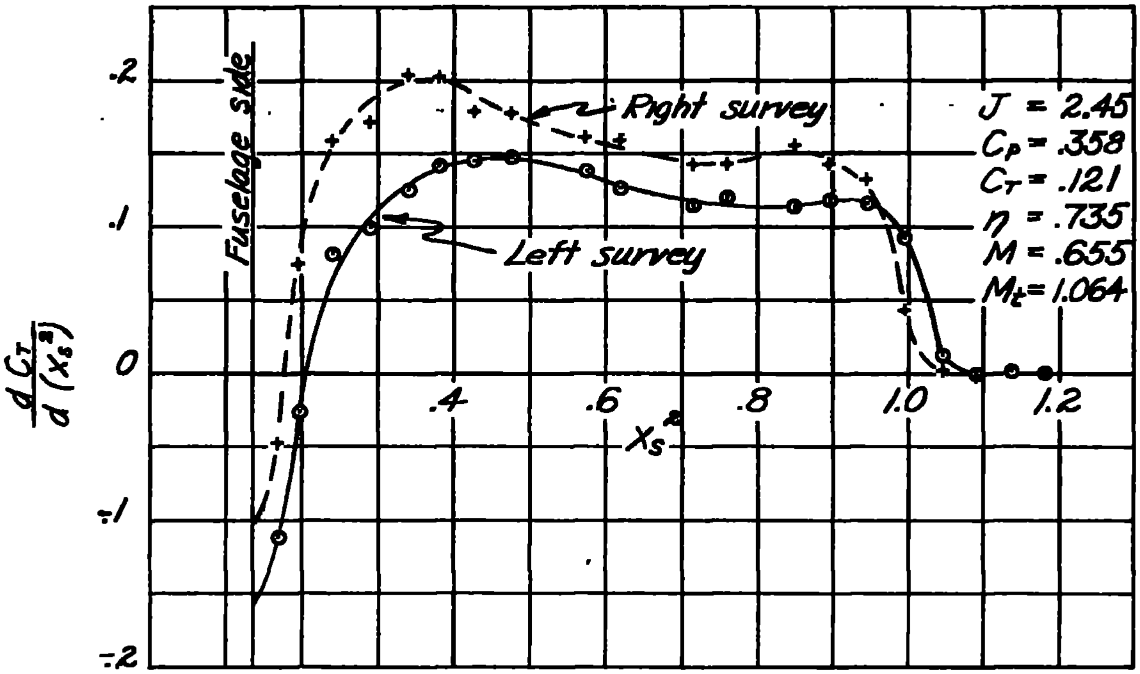


(c) Run 24-1.

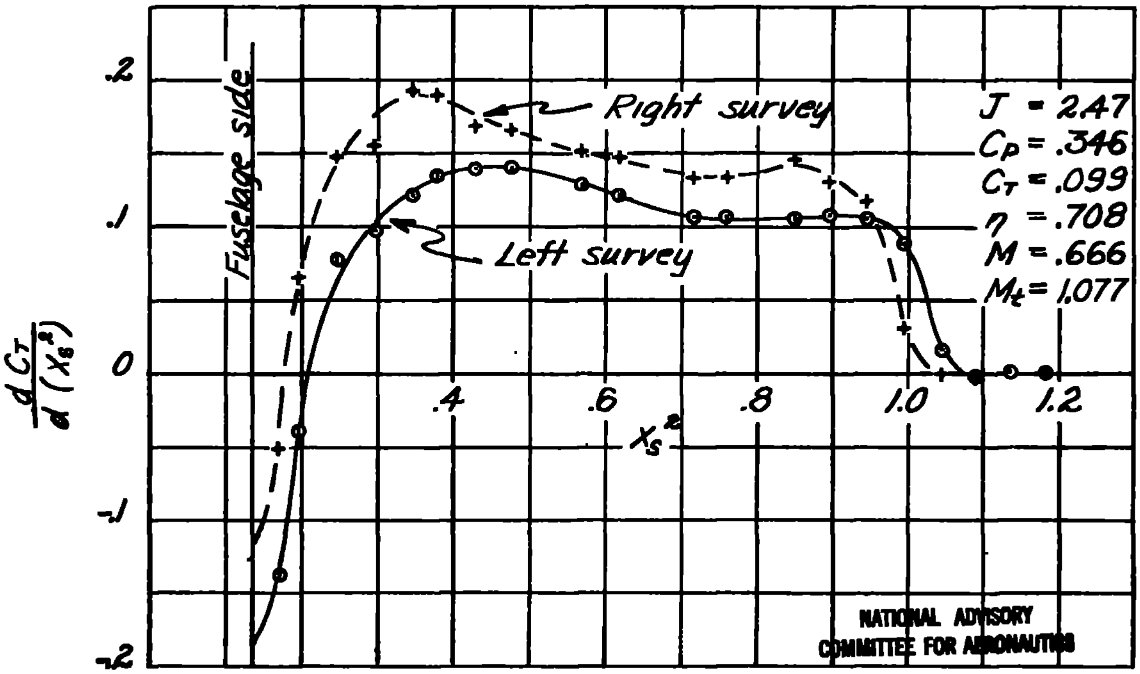


(d) Run 24-2.

Figure 11.- Continued.



(e) Run 24-3.



(f) Run 24-4.

Figure 11.- Concluded.

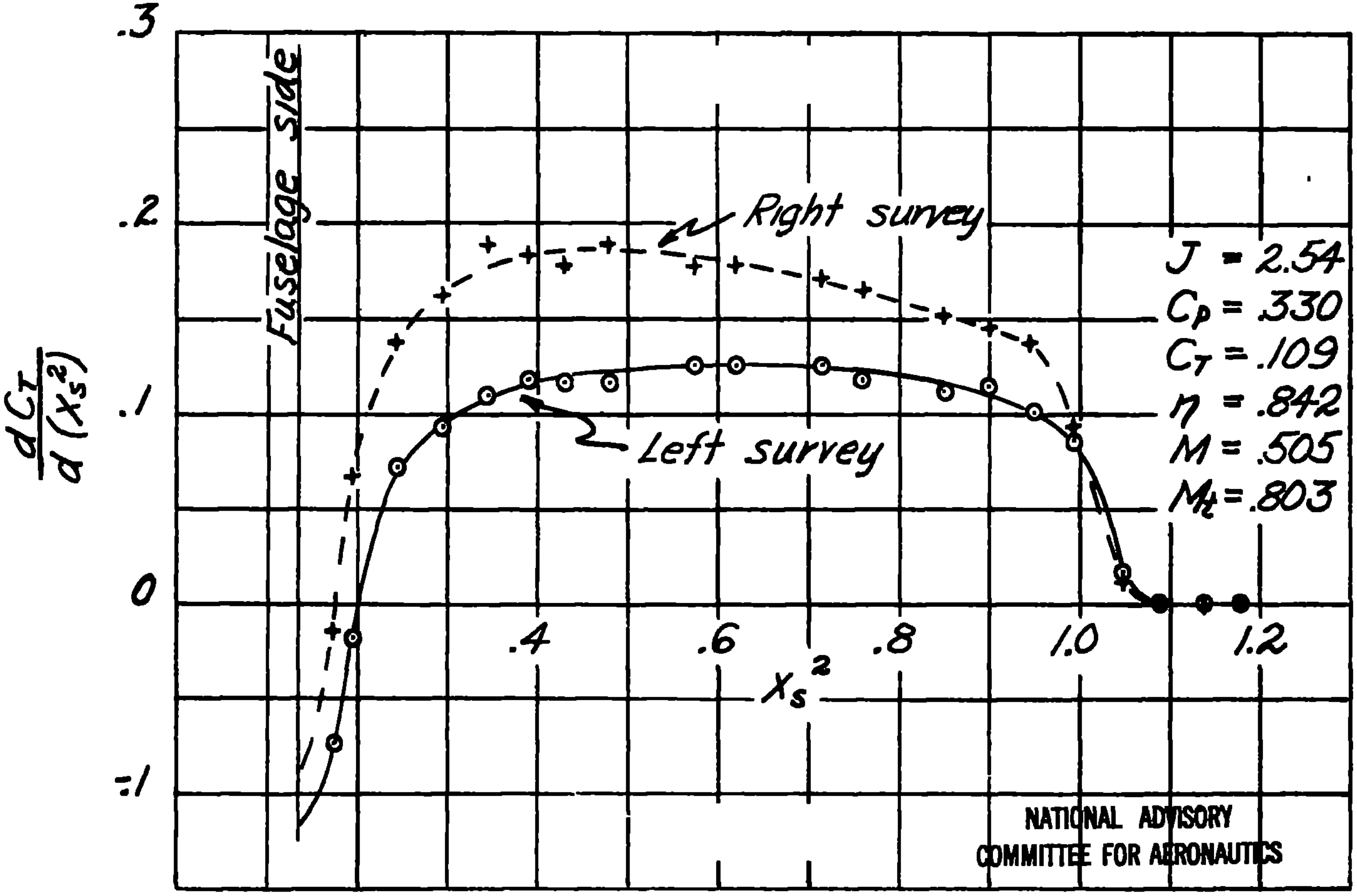


Figure 12.- Thrust-grading curve for run 12-1.

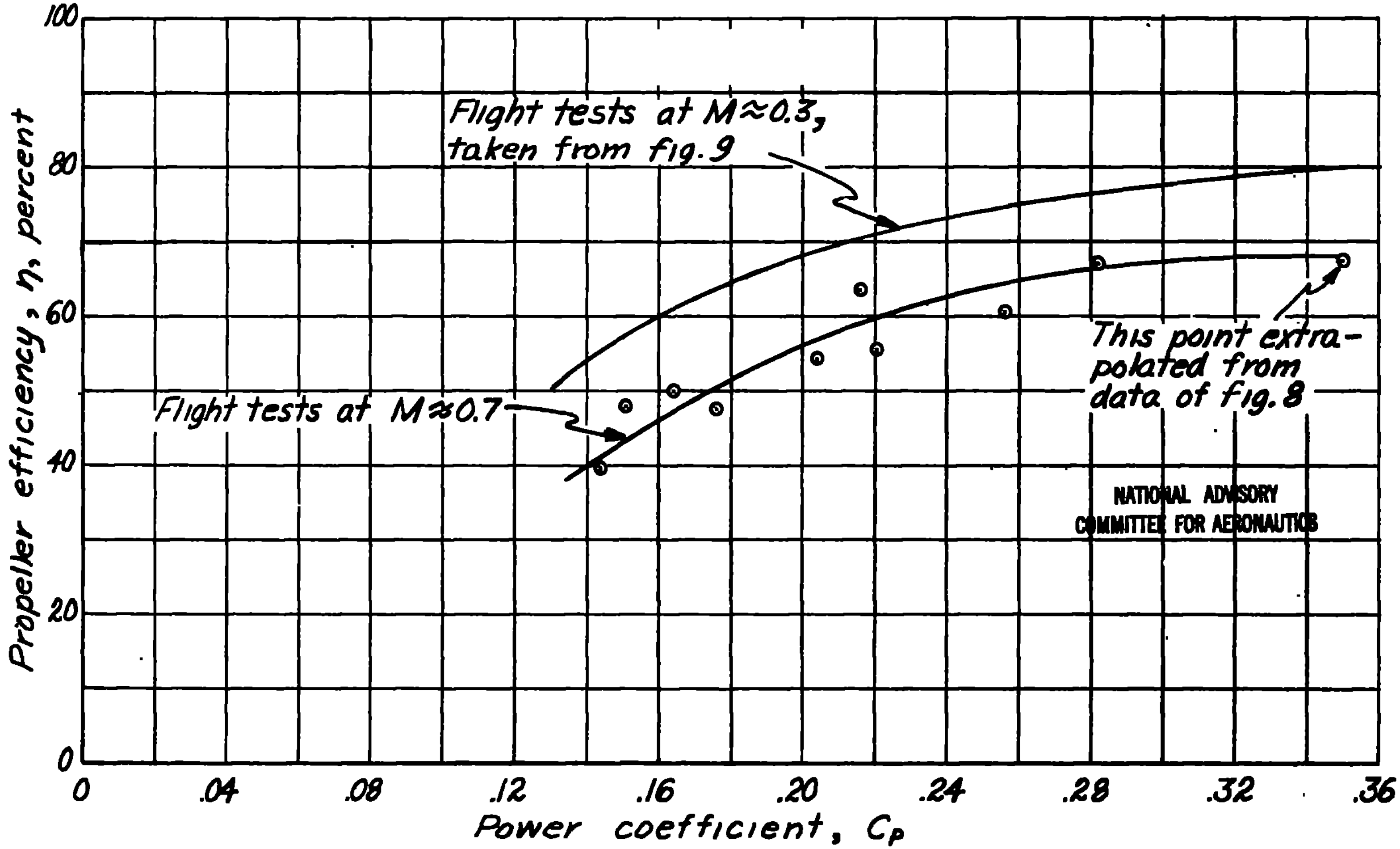
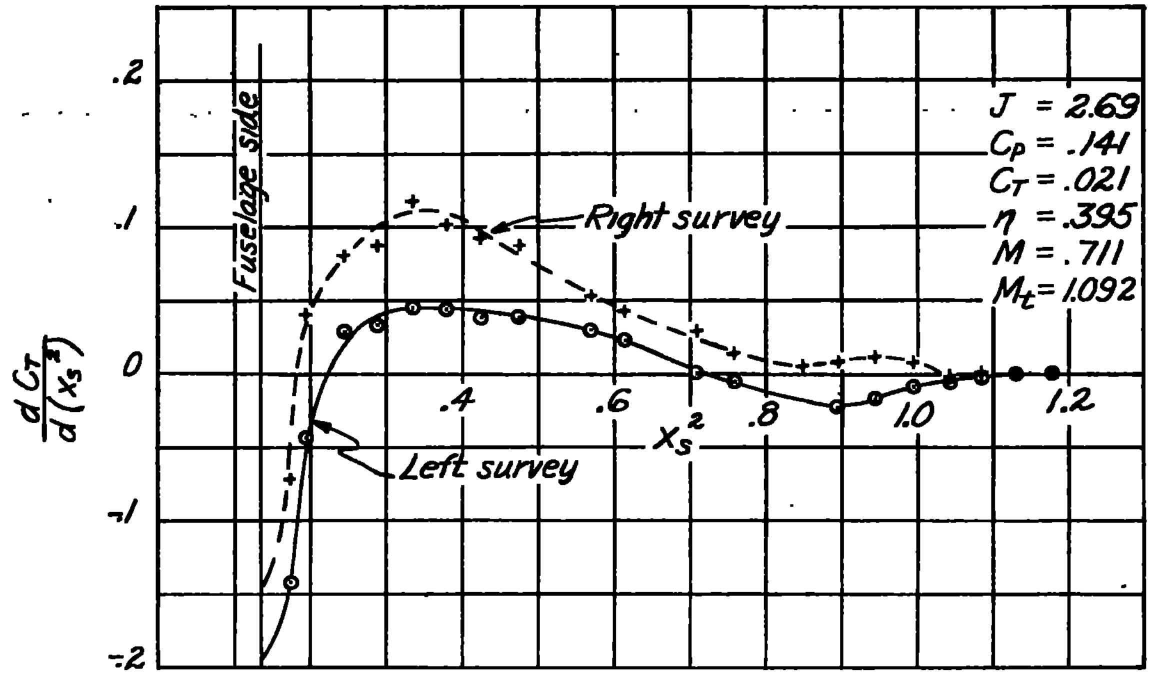
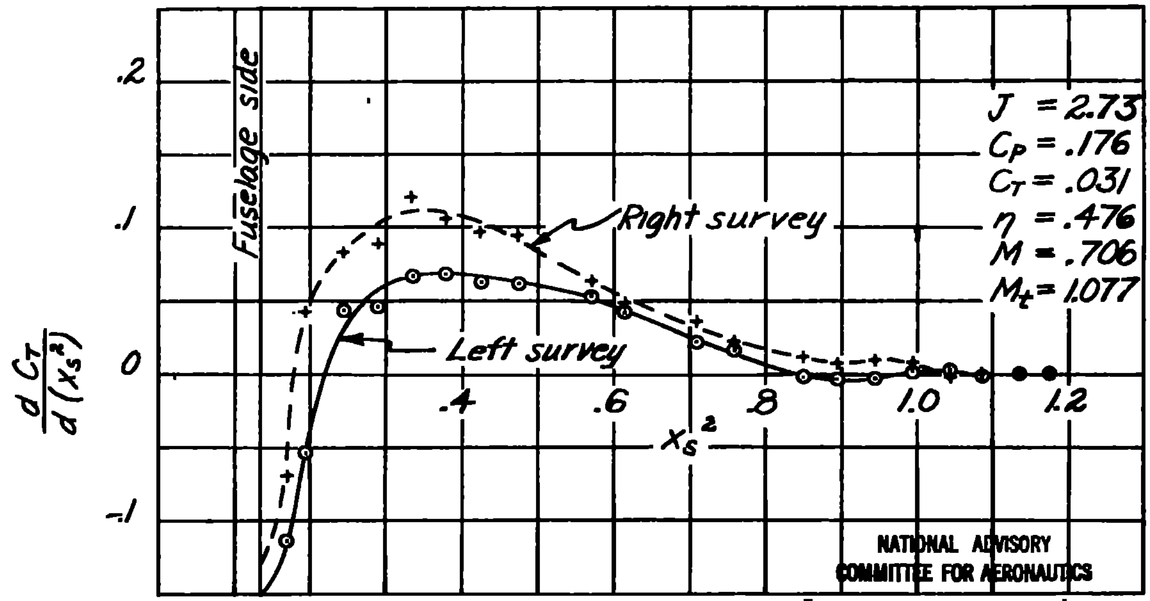


Figure 13.- Effect of blade loading on propeller efficiency at high speed. $J \approx 2.70$.

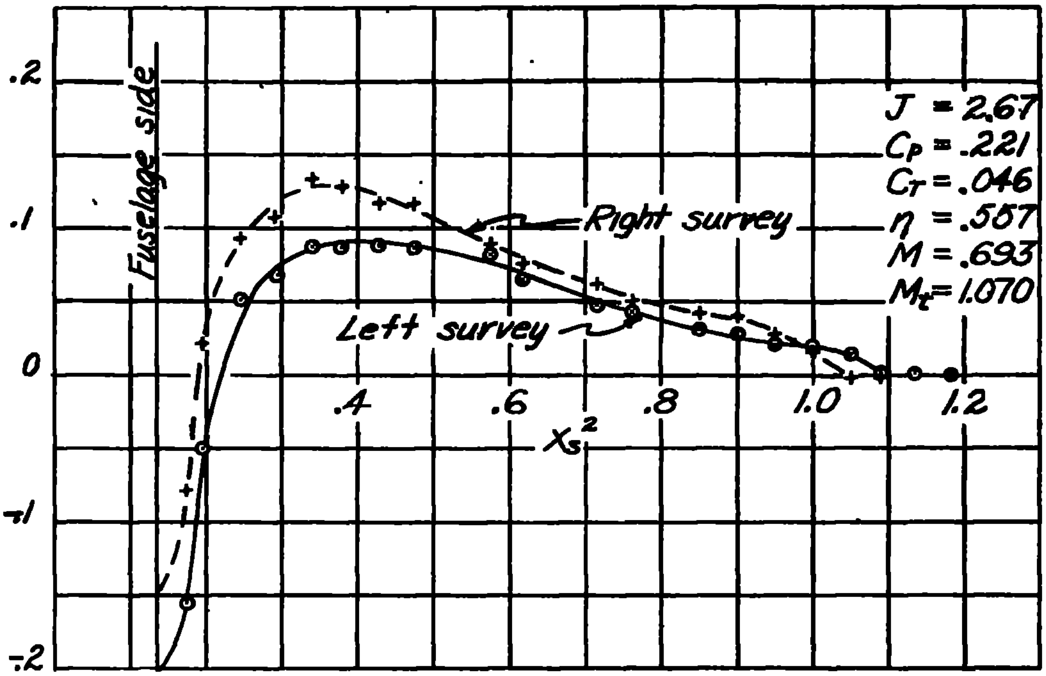


(a) Run 17-1.

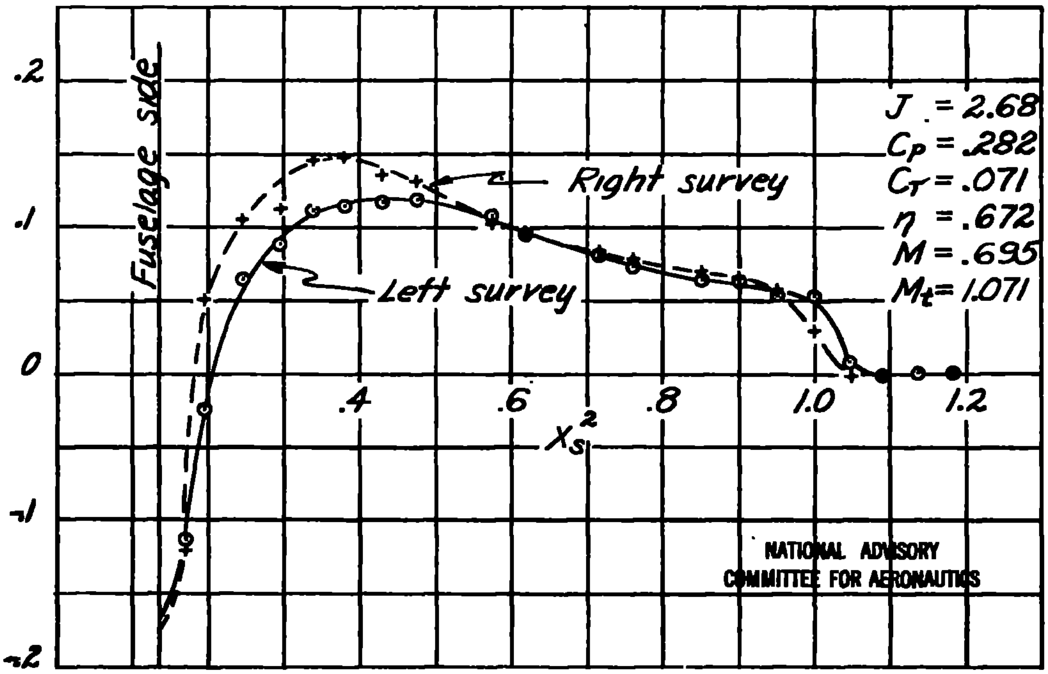


(b) Run 17-4.

Figure 14.- Thrust-grading curves for runs at $J \approx 2.70$ and $M \approx 0.7$.



(c) Run 18-18.



(d) Run 21-9.

Figure 14.- Concluded.

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ADVANCE CONFIDENTIAL REPORT

CLIMB AND HIGH-SPEED TESTS OF A CURTISS NO. 714-1C2-12 FOUR-BLADE PROPELLER ON THE REPUBLIC P-47C AIRPLANE

By A. W. Vogeley

SUMMARY

Flight tests were made of a Curtiss No. 714-1C2-12 four-blade propeller on a Republic P-47C airplane in climb and at high speed. The loss in efficiency when power was increased from normal to military was found to be from 5 to 8 percent in climbs at an indicated airspeed of 165 miles per hour. This loss was attributed primarily to reductions in section lift-drag ratios resulting from increased operating lift coefficients.

In high-speed flight at military power, losses in efficiency due to compressibility started at an airplane Mach number less than 0.4 and increased steadily to 10 or 11 percent at an airplane Mach number of 0.7. These losses were encountered whenever the propeller-tip Mach number exceeded 0.83 and the propeller efficiency decreased at a rate of about 7 percent for an increase of 0.1 in tip Mach number. At an airplane Mach number of 0.7 and constant propeller rotational speed the propeller efficiency decreased with a decrease in power below military power. In comparison with the efficiencies of low-speed flight tests (a Mach number of approximately 0.3) at the same advance-diameter ratio, however, the compressibility loss was relatively independent of power.

The tests indicated that, by suitably increasing the solidity and reducing the rotational speed, it may be possible to improve the propeller efficiency in both climb and high-speed operation.